"Air-conditioning system for rooms"

FIELD OF THE INVENTION

The present invention refers to an air-conditioning system for rooms according to the pre-characterizing portion of claim 1.

BACKGROUND OF THE INVENTION

In order to improve the healthiness of the human body the air of a room within a house should have particular features, for instance an hygrometric degree of 50% to 60%. As a matter of fact, in such conditions the human body can adjust its own temperature through condensing and dissipating mechanisms.

In order to meet such requirements within a house, i.e. to have pleasant environmental conditions, that is to feel warm in winter and cool in summer, two separate independent hydraulic circuits for heating and cooling are necessary, in the first of which hot water and in the second one cold water circulates.

In order to heat or cool the house it is therefore necessary to have a boiler and a cooling unit, each of which is equipped with its own electric and hydraulic supply and with its own control system.

The house should be heated during winter in all the

rooms it is made up of, whereas it should be cooled during summer only in some rooms, i.e. those which are used more frequently, leaving aside for instance the bathroom and the kitchen. This requires quite different operating features in both systems concerning capacity, pump flow rate, pressure drop during water supply and so on.

In order to overcome this disadvantage systems have been developed which can ensure heat and/or cold using the same hydraulic circuit. Indeed, this type of systems is associated with a cooling unit, which works during summer in order to circulate within the common hydraulic circuit cold water bypassing the boiler, and during winter the cooling unit is bypassed so that hot water can flow within said hydraulic circuit.

For instance Patents US 2,121,625, US 2,984,460, US 3,425,485, US 3,906,742, US 4,798,240 and DE 2,140,018 describe central heating and cooling installations comprising a plurality of heat exchangers, each of which being arranged in a room of the various houses. In particular, said heat exchangers are connected to a single boiler and to a single cooling device.

In recent years manufacturers of heating and cooling systems for block of flats or small detached houses have introduced integrated or monobloc systems in

which a single system gathers up the functions of cooler and boiler using a single unit equipped with exchangers.

Such type of systems disadvantageously has a high thermal inertia, which can occur within an air-conditioning system.

The solution suggested by said manufacturers in order to overcome such drawback was to use a system comprising a boiler circulating heating water through the heat exchanging units placed in the rooms to be heated by means of a hydraulic circuit, a cooling module associated to said boiler and an inertial reservoir (also known as storage reservoir).

This inertial reservoir acts as reserve of cooled water allowing to increase the system capacity and to obtain a longer life for cooling machines due to a smaller number of starts of said machines.

The introduction of the storage reservoir therefore enables a higher flexibility due to the possibility of operating also at temperatures slightly differing from design temperature, and above all enables a great operating economy due to the possibility of installing machines with reduced power.

Therefore, when in air-conditioning systems the problem of a low thermal inertia arises, it is sufficient

to place an inertial reservoir between the cooling group and the system. This type of reservoir thus allows to increase the water content of the whole system ensuring a longer interval between the stop of the compressor and a subsequent start, thus highly reducing the number of starts and improving the life and performance of said compressor.

However, since the monobloc unit is bulky, cumbersome and noisy, it should almost always be arranged outside the house to be conditioned, so that during summer the removed heat is not dispersed within the room itself.

This however results in that during winter, in order to avoid the freezing of the water contained within the storage reservoir, particular contrivances should be used in order to prevent possibly destructive damages to the system due to the increase of water volume.

One of the most frequently used solutions provides that the storage reservoir is equipped with a water inlet/outlet valve, i.e. with a valve allowing the reservoir to be completely emptied before winter and with a valve allowing said reservoir to be re-filled before summer.

This results in long and boring filling/emptying operations of the reservoir to be absolutely carried out

to prevent the system from being damaged. However, said solution does not protect the heating and cooling system in case the user forgets to carry out said operations.

Another solution to prevent water contained in the inertial reservoir from freezing consists in using electric heaters, which keep water within the reservoir liquid, thus ensuring that the heating and cooling system cannot be damaged due to the user's carelessness or to a very cold weather.

Electric heaters are for instance electric resistors that in order to carry out their function must absorb electric energy and turn it into heat. Obviously, such a contrivance results in that part of the advantages obtained with a storage reservoir are erased by the dissipation of energy necessary to supply said electric resistors. The dissipation of electric energy will be higher the greater the reservoir volume and the colder winter weather is.

SUMMARY OF THE INVENTION

In the light of the described state of the art, the present invention aims at carrying out an air-conditioning system for external use without the disadvantages of prior art.

A further aim of the present invention is to supply an integrated heating and cooling unit that requires the least possible maintenance by the user.

According to the present invention said aim is achieved by means of an air-conditioning system for rooms according to claim 1.

Thanks to the present invention it is possible to carry out an air-conditioning system that is more efficient and therefore environmentally friendlier than systems of prior art.

Moreover, it is possible to carry out an air-conditioning unit that does not require maintenance operation during season shifts.

BRIEF DESCRIPTION OF THE DRAWINGS

The characteristics and the advantages of the present invention will be evident from the following detailed description of one of its practical embodiments, shown as a mere non-limiting example in the enclosed drawings, in which:

Figure 1 shows schematically a preferred embodiment of the air-conditioning system according to the present invention;

Figure 2 shows schematically a layout of a component of Figure 1, in particular a layout of a gas

boiler;

Figure 3 shows schematically a first operating configuration during summer of the air-conditioning system of Figure 1;

Figure 4 shows schematically a second operating configuration during winter of the air-conditioning system of Figure 1.

Figure 1 shows schematically an embodiment of the present invention consisting of a block 1 comprising a cooling circuit 2, a control unit 3 and a storage reservoir 4, a heating system 8 associated to said block 1 and a plurality of fan-convectors F1, ..., Fn.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The block 1 and the heating system 8 thereto associated constitute the monobloc system that integrates all components for heating/conditioning the house.

As can be noted from the diagram in Figure 1, the cooling circuit 2 is connected by means of a connection pipe A to a three-way switching valve V1, the latter being able to connect said cooling circuit 2 to a plurality of fan-convectors F1, ..., Fn by means of a intake pipe 5.

Said cooling circuit 2 is further connected by means of a connection pipe B to a circulation pump P1; said

circulation pump P1 takes water to circulate in the cooling system 2 from the storage reservoir 4 by means of a connection pipe C.

Said storage reservoir 4 is connected in its turn to a plurality of fan-convectors F1, ..., Fn by means of a return pipe 7.

Furthermore, as can be inferred from the diagram of Figure 1, the storage reservoir 4 has in common with said plurality of fan-convectors F1, ..., Fn the connection to the heating system 8, which takes place by means of a connection pipe D.

Therefore, the connection pipe D is the extension of the return tube 7 of the fan-convectors F1, ..., Fn.

The control of the cooling circuit 2, of the fan-convectors F1, ..., Fn as well as of the heating system 8 is in charge of the electronic control unit 3, said control unit 3 being able to control all devices by means of a plurality of electric connections 9 in a per se known way.

By analyzing in further detail what is included within the cooling circuit 2, the latter consists of a compressor 10, of a capacitor 11, of a lamination element 12 (or capillary) and of an evaporator 13, each of said components being connected to the other by means of connection pipes E.

The compressor 10 is the core of the cooling circuit 2 and its function is to compress a cooling fluid, for instance freon or halogenated fluids, and to bring it to high pressure by heating it.

In the present invention, for instance, a rotary compressor is used, whose great advantage with respect to traditional compressors is the absence of alternating movements and therefore of vibrations, thus ensuring silence and absence of vibrations to the user's immediate comfort.

Downstream from the compressor 10 an exchanger 14 is connected, on which a fan 15 is axially placed.

Said exchangers 14 are finned-tube exchangers and consist for instance of tubes made of scored copper or of stainless steel. The fins of the exchangers (not shown in Figure 1) can be made for instance of aluminum, copper or aluminum treated for environments with aggressive agents.

At the outlet of the exchangers 14 the cooling fluid, which is liquid, gets through the lamination element 12.

The lamination element 12 (also known as capillary) enables, as is well known, the expansion of the fluid and further allows to adjust the flow rate of said fluid.

Said lamination element 12 consists for instance of a copper tube with a length of 1-2 meters, wound on itself and having a diameter of some tenths of millimeter.

It should also be noted that the lamination element 12 is preceded by a dehydrating filter 12a and is followed by a silencer 12b. The function of the dehydrating filter 12a is to eliminate water residues from the cooling fluid, thus ensuring the compressor 10 a longer life, whereas the function of the silencer 12b, which can be for instance an absorption or resonance silencer, is to soften noises made by the cooling circuit 2 as a whole.

The passage of the cooling fluid through the tube constituting the lamination element 12 results in a pressure reduction, without allowing a heat exchange with outside. The cooling fluid is therefore brought to an evaporation temperature, which is far lower that room temperature.

The cooling fluid gets through the evaporator 13, which is carried out for instance using the technology, well known to a technician skilled in the art, of exchangers with welded-brazed plates.

The evaporator 13 is structurally the same as the capacitor 11 but has an exactly symmetrical function

with respect to the latter; here the cooling liquid changes in opposite direction, i.e. shifts from liquid to vapor by absorbing heat from the environment.

Therefore, the cooling fluid overheated at a high pressure gets from the compressor to the capacitor, then starts giving heat to the colder room air getting through it, i.e. at first temperature sinks due to the discharge of sensitive heat, until the state of saturated vapor is reached, i.e. constant pressure P and temperature T. This stage is followed by the condensing of the fluid, i.e. the state shift, from vapor to saturated liquid by means of the plate evaporator 13.

To summarize, the working of the cooling circuit 2 provides that the compressor 10 compresses the cooling fluid (here as gas) at low temperature and pressure, for instance T = +7°C and P = 5 bar, and brings said cooling fluid, always as gas, to high temperature and pressure, for instance T = 100°C, P = 16 bar.

From now on the cooling fluid is sent to the capacitor 14 by means of the connection pipe E, which is also for instance made of copper, and within said device take place first the cooling, for instance up to about T = 40°C, and then the state shift from gas to liquid, with the consequent heating of outside air.

During this stage the latent heat of condensation is

given to a colder outside fluid, i.e. air in our case. After the capacitor 14 the cooling fluid, now liquid, though always at high pressure, gets through the lamination element 12, which as already described is a capillary, thus turning from high pressure, for instance P = 16 bar, to low pressure, for instance P = 5 bar, though always liquid.

The cooling fluid, now liquid, at low pressure and low temperature, for instance P = 5 bar and T = +7°C, gets out of the condensing unit and is led to the evaporator 13 through connection pipes.

Within the evaporator 13 evaporation at low pressure and low temperature takes place, i.e. little below P = 5 bar and T = +7°C, so that the cooling fluid shifts from vapor to liquid, boiling and absorbing heat. Thus the fluid with which it is put in contact through the walls of the evaporator 13 cools down, i.e. the air of the room, which is thus cooled.

The cooling fluid must turn completely into gas within this evaporator and then, by getting through the connection pipes in the opposite direction, gets back to the compressor 10.

It should further be noted that the cooling circuit described above from the static and dynamic point of view can also comprise other devices so as to work as

a heat pump.

In this case the lamination element 12 consists, as is well known to a technician in the field, of a capillary for cold operation, an additional capillary for heat pump operation and a unidirectional bypass valve.

A four-way valve for cycle inversion and a storage reservoir for cooling liquid should also be present.

The cooling circuit 2, as already described, is connected to the fan-convectors F1, ..., Fn through the three-way switching (or mixing) valve V1 by means of the intake pipe 5.

The valve V1 is equipped with an electric motor (not shown in Figure 1), and on the basis of the electric signals sent by the electronic control unit 3 to said electric motor (which can be for instance an incremental motor) said three-way valve V1 can be opened/closed.

This can be obtained thanks to the shifting of a shutter (not shown in Figure 1), so as to create a sort of narrowing of the fluid pipes with subsequent distribution of water flows in the intake pipes.

The valve V1 therefore allows the fluid connection through the intake pipe 5 to the fan-convectors F1, ..., Fn acting as heating/cooling terminals whose radiant kit will be supplied according to the present

invention with hot water during winter and with cooled water during summer.

These fan-convectors F1, ..., Fn generate a forced air flow by means of the fan 16 they are equipped with, which flow involves the whole room generating an active air circulation, preventing the formation of stagnant areas and stratifications and keeping a pleasant and uniform air movement.

Each fan-convector F1, ..., Fn is equipped with a thermostat (not shown in Figure 1) so as to adjust temperature and with a speed variator for the fans 16 allowing to choose the speed of thermal adjustment for the room.

Thus this type of installation allows the user to control the air-conditioning wholly independently for each room, though it is a centralized system.

The three-way switching valve V1 is also connected, as already described, to the connection tube D acting as return tube of the heating system 8.

The heating system 8 can be for instance an independent gas boiler or a centralized installation or a district heating system (not shown in Figure 1).

Figure 2 shows the layout of a gas boiler comprising an inner hydraulic circuit including a heat exchanger 17, a series of burners 18 supplied by a tube 19 in

which a throttle valve 20 is arranged, a circulation pump 21, a hot water heater 22 for domestic hot water getting into the tube 23 and out of the tube 24 through the tap 25, an expansion vessel 26, a three-way valve 27 and a throttle valve 28 to bypass the boiler during summer.

The boiler 8 comprises also the connection pipe D acting as intake tube and the connection pipe E acting as return tube for the connection to the cooling circuit 2.

The three-way valve 27 is controlled by a transducer 29 fitted into the outlet tube 24 of the hot water heater 22. This transducer 29 automatically switches the three-way valve 27 so as to put in communication hot water getting out of the heat exchanger 17 with the hot water heater 22 whenever the tap 25 is opened for supplying hot water for domestic use.

Examining now Figures 3 and 4, which show schematically a first and second operating configuration, during summer and during winter respectively, of the air-conditioning system of Figure 1 according to the present invention, it can be advantageously noted that the central branch of the three-way switching valve V1 is always connected to the inlet or intake branch 5 of the fan-convectors F1, ..., Fn.

As a matter of fact, referring in particular to Figure 3, i.e. to the working of the installation of Figure 1 during summer, the working of the air-conditioning system provides that the throttle valve 28 is closed and that the cooling circuit 2 is operated by the control unit 3 so as to circulate the cooling fluid within the heat exchanger in said cooling circuit 2.
The three-way valve V1 is switched by the control unit 3, i.e. by the electronic control unit, so as to connect the connection tube A of the cooling circuit 2, more precisely the outlet tube of the evaporator 13, to the fan-convectors F1, ..., Fn through the intake tube 5.
Simultaneously, the control unit 3 actuates the pump P1 so that water coming back from the fan-convectors F1, ..., Fn gets through the evaporator 13 of the cooling circuit 2 and then reaches the finned-tube exchanger 14. The refrigerated water is stored in the storage reservoir 4 before reaching the batteries of the fan-convectors F1, ..., Fn.
In other words, the storage unit 4 acts in this first operating configuration as storage unit for cold water getting out through the connection pipe B in the evaporator 13 to enter into the intake pipe 5 of the fan-convectors F1, .., Fn.

Cold water, after getting through the fan-convectors F1, ..., Fn, is led back through the return pipe 7 into the storage reservoir 4 so as to be re-circulated through the evaporator 13 by means of the pump P1.

Since the fans 16 of the fan-convectors F1, ..., Fn can be operated separately by the control unit 3, it is possible to cool during summer either all rooms in the house or only the rooms chosen by the user.

For instance it is possible to cool during the day only the living-room by operating the fan 16 of the fan-convector placed in the living-room, and during the night only the bedroom by operating the fan 16 of the fan-convector placed in the bedroom, while cold water is circulated in all fan-convectors F1, ..., Fn.

Obviously, the cooling circuit 2 includes, as is well known to a technician in the field, all safety devices, not shown in Figures 1-4, that are required by the regulations on accident prevention.

Referring now to Figure 4, i.e. to the working of the installation of Figure 1 during winter, it should be noted that water coming back from the fan-convectors F1, ..., Fn through the return pipe 7 is deviated by the three-way valve V1 so as to reach the boiler 8 through the connection tube C.

The boiler 8 allows to heat the rooms of each detached

house or block of flats since water within the hydraulic circuit leading to the fan-convectors F1, ..., Fn (i.e. intake tube 5) is circulated by the pump 21 within the boiler 8.Hot water can thus circulate in the fan-convectors F1, ..., Fn and therefore heats the rooms of the house, whereas the cooling circuit 2 according to the present invention is bypassed by means of the three-way valve V1.

As a matter of fact, the control unit 3 does not switch on the pump 1 and the cooling circuit 2.

Advantageously, in this second operating configuration the storage reservoir 4 does not act any more as cold water storage unit but as thermal inertia for water contained within the evaporator 13.

As a matter of fact, should water heated by the boiler 8 reach directly the evaporator 13, the cooling fluid therein contained would reach extremely high pressures that are not compatible with the characteristics of mechanical and thermal resistances of said evaporator 13.

Since the cooling unit, i.e. the block 1 comprising the cooling circuit 2, the control unit 3 and the storage reservoir 4, is placed outside the house, no problem arises involving the freezing of the connection tubes during winter, because the latter do not

contain water but a cooling fluid that does not freeze.

As far as the storage reservoir 4 is concerned, the latter does not freeze during winter because hot water coming back from the fan-convectors F1, ..., Fn heats by convection the content of said reservoir 4 preventing its freezing.

This can take place since water coming back from the fan-convectors F1, ..., Fn is at a temperature of about T = 60°C, and by exploiting the configuration of the new hydraulic circuit it is possible by means of the convective effect, convection being a phenomenon involving typically fluids by means of macroscopic substance transport, to heat water contained in the storage reservoir 4 without using auxiliary solutions and/or devices.

Thus, hot water within the return tube 5 of the fan-convectors F1, ..., Fn by convection can keep water contained in the storage reservoir 4 liquid (i.e. prevents its freezing) also during winter.

Thanks to the present invention it is possible to obtain a storage reservoir 4 without inlet/outlet tap and/or electric heaters, thus carrying out an air-conditioning system that is more efficient and therefore environmentally friendlier than installations of

prior art, and further carrying out an air-conditioning system that does not require maintenance operating during season shifts.